



(Re)presenting urban heat islands in Australian cities: A study of media reporting and implications for urban heat and climate change debates

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ABSTRACT

The effects of climate change and urban heat islands are predicted to grow and compound in the future. In the context of urban heat becoming an increasing problem, this article explores the extent to which this is recognised in media. Our findings show that the issue of the urban heat island (UHI) effect appeared on media agendas over the period studied and that predominantly the issue of UHI was framed in four ways. The *top-down mitigation frame* focused on the proactive approach of local governments while highlighting inaction at state and national levels. The *bottom-up mitigation frame* presented a patchwork approach to dealing with UHI with a positive focus on the mitigation actions of individuals and the private sector, while the *risks and vulnerabilities frame* looked at the distribution and mapping of the health risks posed by the phenomena. However, the media analysis also highlighted two factors which have potentially negative consequences regarding science communication and citizen understandings of science. These are the ambiguous and/or cautious manner in which the UHI effect is referred to and the use of UHI as an alternative argument to climate change in the *climate change debate frame*.

1. Introduction

Heatwaves kill more people than any other natural disaster in Australia. In the future, due to the impacts of climate change, we are expected to experience an increase in frequency and severity of heatwaves. Over the next 20 years, the population of Greater Sydney is expected to grow by 1.6 million, including 900,000 in Western Sydney (Greater Sydney Commission, 2016), which is geographically isolated from the ocean and is already hotter than coastal locations. Increased urbanization is predicted to exacerbate the effects of climate change by causing localized warming known as the Urban Heat Island (UHI) effect (Janković and Hebbert, 2012; Argüeso et al., 2015; Levermore et al., 2017), also referred to more broadly as urban heat (Coutts et al., 2016).

The UHI effect is defined as the difference in observed ambient temperature between urban and peri-urban environments due to the presence of urban structures and infrastructure materials (Adams and Smith, 2014; Phelan et al., 2015). The formation of an UHI has environmental, health, social, and economic consequences. These include the decreased productivity and performance of workers, the altered typology, duration and frequency of outdoor activities (Sharifi et al., 2016), the increased initiation of storms/precipitation, a rise in energy demand, the emission of greenhouse gasses and other air pollutants (Deilami et al., 2016; Santamouris et al., 2015), air (Sidiqi et al., 2016) and water pollution (Phelan et al., 2015), the reduced health and comfort of citizens, and the

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increased intensity and duration of heat waves (Sachindra et al., 2016).

Experience with many environmental issues highlights the importance of engaging people (McManus, 2000), including through media. This article investigates how media discussion around the issue of UHI is potentially shaping public knowledge of this phenomenon, firstly by considering the degree to which the public has been made aware of the UHI effect through media, and secondly by considering how do media report on the issue. The article begins with a literature review of the UHI effect, followed by a review of media studies and framing. We then introduce the research methods employed in this study of media in Australia. The results of this media study are presented, and then analysed in relation to how the issue of urban heat is framed.

2. UHI causes and solutions

Due to the complex nature of the urban heat island (UHI) effect, it is inherently difficult to adequately define, measure and/or model the phenomena without oversimplification. A review of the literature indicates that there is also uncertainty regarding the most significant cause of the UHI effect. Solar energy has been deemed the largest contributor to the UHI effect (Wong et al., 2013), however significant quantities of heat are also generated from indoor air-conditioning systems (Sharifi et al., 2016), low albedo building materials (Razzaghamanesh et al., 2016), impervious urban surfaces, (Argüeso et al., 2014), the inhibition of evaporative cooling by urban surfaces, and the reduction of the sky view factor (Argüeso et al., 2013). Urban characteristics, synoptic conditions, local meteorological features, specific urban materials, the presence (or lack) of green spaces (Akbari et al., 2016), and low wind speeds across urban areas (Sachindra et al., 2016) are also deemed to be significant contributors to the UHI. The UHI effect is also multi-casual on a smaller scale, with a considerable number of interconnected factors being identified as potential causes and/or influencers of the UHI effect. These factors can be summarised as physical, structural, and morphological characteristics of the built environment, meteorological and climatic conditions, and human activities.

It is vital that the full extent of the UHI effect is understood thoroughly as it potentially has numerous environmental, health, social, and economic consequences. Health impacts will likely occur at different levels among regions and population sub-groups (Zografos et al., 2016). This reflects the influence of environmental and socioeconomic circumstances, infrastructural and institutional resources, and local preventative strategies on patterns of disease (Bambrick et al., 2008). Most concerning, from an environmental justice perspective, is that urban heat stress appears to disproportionately affect vulnerable groups by increasing their chances of suffering from direct heat related mortality and morbidity (Patz et al., 2005; Loughnan et al., 2012). These vulnerable groups include infants and children, seniors (Nicholls et al., 2008; Sharifi et al., 2016; Taylor et al., 2015), low income earners (Hondula and Barnett, 2014), those with poor English language skills, the homeless, and indigenous communities (Kjellstrom and Weaver, 2009). Temperature changes may also affect the distribution of most arboviruses, the geographic region suitable for the transmission of dengue, the transmissibility of several vector-borne diseases, and the incidence of diverse climate-sensitive infectious diseases (Bambrick et al., 2008).

Given the multifaceted nature of the urban heat island effect there is no clear solution to the problem. It seems the development of a suite of carefully considered compensatory management and/or mitigation strategies will be most effective at addressing its causes and effects. Introducing greenery or urban green infrastructure (UGI) in cities is seen as the most effective strategy for mitigating the UHI effect (Lehmann, 2014; Norton et al., 2015; Livesley et al., 2016; Lin et al., 2016). UGI can be defined as a network of planned and unplanned green spaces, spanning both the public and private realms, and managed as an integrated system to provide a range of benefits (Norton et al., 2015). Benefits include reducing the amount of solar radiation absorbed into building materials such as walls, roofs, and pavements (Lin et al., 2016), improving air quality, reducing noise pollution, improving social wellbeing and safety, and improving the adaptive capacity of public spaces and their outdoor environments (Sharifi et al., 2016). Research has also focused on the benefits of using ‘Water Sensitive Urban Design’ as a mitigation strategy to lower the magnitude of the UHI effect (Coultts et al., 2012). Successful mitigation of the UHI effect would decrease the cooling energy used in buildings, make outdoor pedestrian environments more comfortable, and slow down the smog photochemical reactions currently causing health problems (Akbari et al., 2016).

Within the Australian context research interest in the UHI has been increasing in recent years. Evidence of the UHI effect has been identified in the major cities in Australia, with high density regions recording the highest temperatures (Neave et al., 2016). Many studies focus on the UHI effect in and around Melbourne (Coultts et al., 2007; Loughnan et al., 2012; Coultts et al., 2016), with a smaller number of studies concentrating on Adelaide (Erell and Williamson, 2007; Sharifi et al., 2016), Brisbane (Deilami et al., 2016; Deilami and Kamruzzaman, 2017), the Gold Coast (Byrne et al., 2016; Ambrey et al., 2017), and Canberra (Mahmuda and Webb, 2016). The number of studies conducted in Sydney have been steadily increasing (Lehmann, 2014; Argüeso et al., 2015; Sharifi and Lehmann, 2015; Sidiqi et al., 2016; Santamouris et al., 2017).

Evidently, the effect is gaining increasing attention both from a scientific point of view (as detailed above) and from a governance perspective. Internationally Klok and Kluck (2016) detail how a range of cities are using governance mechanisms to respond to the challenges of increasing urban heat. The importance of government actors is further identified by Hintz et al. (2017, p. 1) whose review of UHI literature ‘highlights city administration as pivotal actor for implementing solutions and emphasizes the importance of inhabitants as well as local governments as essential actors for adaptation to urban heat waves.’ In Sydney local governments and state planning bodies are beginning to recognise UHI effect as an increasing phenomenon in urban areas that requires local action and planning to address (Office of Environment and Heritage, 2016; Greater Sydney Commission, 2016; WSROC, 2016). With this in mind this article asks the question to what degree has the public been made aware of the UHI effect through media and how does media report on the issue?

3. Agenda-setting, framing and critical discourse analysis (CDA)

Agenda-setting theory, originating in 1972, espouses that media are influential in setting particular public bias towards certain issues (McCombs and Shaw, 1972). The theory has since been developed to include significant emphasis on framing (also known as second level agenda setting). As Scheufele (2000, p. 298) explains, agenda setting is ‘concerned with the salience of issues’ while framing is ‘concerned with the salience of issue attributes’. Frames are, therefore, typically understood as the contextual understanding through which the embedded media message is communicated. As such, analysis of framing allows for a more nuanced exploration of particular issues. Within media studies the method of frame analysis can vary significantly depending on whether the frames are analysed inductively through methods such as; the hermeneutic approach, the linguistic approach or the holistic approach or deductively and whether frame coding is done manually or through computer software (Matthes and Kohring, 2008; Matthes, 2009). This variance in method has been noted by some as an issue of concern (Matthes and Kohring, 2008; Matthes, 2009).

A related field, critical discourse analysis, uses dialogical and discursive approaches to distil the intent of media sources. The process of critical discourse analysis (CDA) positions language as a tool for interpreting the social and natural environment. It reflects the physical, social and mental world of which society is constructed (Fairclough, 2003). Consequently, CDA is a method in which meaning, overt and subtle, is explored in written or visual medium (Johnstone, 2002). Pertinently, Fairclough (2003, p. 85) identifies news as an ‘apparatus of governance’. Here ‘governance’ is meant by Fairclough in a broad sense incorporating ‘markets, hierarchies and networks’ (Fairclough, 2003, p. 32). This lens of discourse analysis draws attention to how narrative structure and framing is ‘oriented to regulating and controlling events, and the ways in which people respond to events’ (Fairclough, 2003, p. 85). The importance of this perspective should not be understated as discourse shapes opinions and attitudes (Moyo, 2010), thus having implications for policy and individual world views.

The importance of the role of mass media has become increasingly noted in the field of geography/environmental science since 1990 (McManus, 2000). In this area of study, media discourse analysis has proven efficient in highlighting issues of power and distribution of power (McManus, 2000; McManus and Montoya, 2012; Montoya et al., 2012; McManus, 2015). Furthermore, from a broader interdisciplinary perspective, significant scientific issues and related policy options have been analysed through framing and media narratives (Boykoff and Boykoff, 2007; Rivenburgh, 2011; Crow and Lawlor, 2016). These articles illustrate how media frames complex issues and theorise the impacts of this framing on public perception.

Due to the complexity of the problem and its politicisation, climate change is often the subject of media studies (Boykoff and Boykoff, 2007; Sampei and Aoyagi-Usui, 2009). The interplay between climate change, politics and media in Australia highlights the contentious nature of climate change within the Australian social-political sphere (Gurney, 2016). The role of journalists and journalistic practice have been identified as important aspects of environmental journalism due to the subtle and compounding factors which shape publication (Bacon, 2013). In the Australian context, important factors influencing content include;

media ownership, company and publication cultures, ideological influences, political goals of publications, informal editorial policies and selection of reporters and columnist, professional reporting practices including selection of sources and choice of language... (Bacon, 2013, p. 40).

It is therefore important that these factors be considered when reviewing issue-focused media content. This issue is further exacerbated by the communication gap that has been identified to exist between scientists and journalists (Maillé et al., 2010; Rivenburgh, 2011; Ashwell, 2016). Urban heat is an issue similar, and related to, climate change in media reporting. Our research investigated this relationship because the power to define and represent is a crucial element in shaping opinion and public debate.

4. Research methods

The media review considered the key search phrases ‘urban heat island’, ‘urban heat’ and ‘heat island’ in the six-year period between the 1st of January 2011 and the 31st of December 2016 within the Sydney region (refer to Table 1). Diversity in geographical scale was the guiding factor for the selection of publications reviewed in this media analysis. We included a national daily

Table 1

A list of all media sources used for the study, their geographical scope/positioning, days of publication and ownership. In cases where the online media versions were included in the analysis the geographical positioning and frequency constraints did not apply.

Source	Geographical positioning	Frequency	Ownership	No. of articles published
Sydney Morning Herald Print and Online	Sydney and NSW	Daily	Fairfax Media	63/ ^a 49
The Australian Print and Online	National	Daily	News Corp Australia	21/ ^a 17
The Daily Telegraph (Sydney) Print and Online	Sydney and NSW	Daily	News Corp Australia	12
Inner West Courier	Inner Western Suburbs of Sydney	Weekly	News Corp Australia	4
Parramatta Advocate	Parramatta Area	Weekly	News Corp Australia	3
Blacktown Advocate	Blacktown Area	Weekly	News Corp Australia	3
Penrith Press	Penrith Area	Weekly	News Corp Australia	11
Green Left Weekly Online	National	–	Independent	1
				Total:118/ ^a 100

^a Total number count excluding duplication of articles between online and print articles from the same publisher.

publication, two state level daily publications (a ‘quality newspaper’ and a tabloid), a national weekly left-wing paper, plus four local area newspapers forming a transect of Sydney from the inner west through Parramatta and Blacktown to Penrith. In this way emphasis was given to selecting local media sources in Sydney where UHI is significant. The authors are aware that this study presents a particular transect of UHI reporting both because of its geographic and temporal specificity, however these factors have been duly acknowledged as the parameters of this qualitative study. Nevertheless, it is recommended that further research be conducted in other geographic locations to investigate the similarities and difference in UHI reporting in diverse contexts.

A combination of Factiva and Google were used to search for print and online articles respectively. Both search engines were restricted by date, paper of publication and relevance to search phrase. Seven online articles were picked up in the 2016 search results that were embedded with an infographic video explaining how the UHI effect worked, however no reference was made to the term within the text of the article so these articles were excluded from the reviewed media data. The results of this review are presented in Table 1, which shows the number of results per publication over the six year period. Publication duplicates between sources were included to give an idea of geographic distribution between media results.

The articles listed above were then analysed for the manner in which UHI was framed in the text. Frames were identified through inductive text-based analysis and manual coding based on prominent thematic elements, also referred to as ‘the salience of issue attributes’ (Scheufele, 2000, p. 298). The construction of the frames within this paper was based on previous work by Scheufele (2000), McManus and Montoya (2012), Matthes and Kohring (2008) and Crow and Lawlor (2016) as previously discussed in Section 3 of this paper. Media frames were identified using a hermeneutic approach (Matthes and Kohring, 2008). While this was a subjective process, to ensure constancy the frames were identified through mutual agreement of three researchers by asking three key questions of the text: Who were the dominant actors in the text and how was their role framed in relation to the issue? And from what perspective was the issue discussed? As such, the identification of the frames became clear upon careful reading of texts. While this methodology has been criticized for a lack of transparency in the development of frames (Matthes and Kohring, 2008), a deliberate effort was made to increase transparency by noting detailed descriptions of what constituted frames and the significant considerations in the process – refer to Table 2. This method gives an indication of which frames were most prominent and allows for each frame to be further analysed through Critical Discourse Analysis (CDA); a linguist style approach which considered tone, expression and use of language (Fairclough, 2003; Matthes and Kohring, 2008). In regard to the quantification of the framing analysis, duplications were excluded; articles appearing both online and in print or in a second source were only counted once. The results of this analysis are discussed in Section 5 below.

5. Results

In total the above methodology generated 95 different articles, excluding duplications between online and print media of the same source ($n = 18$) and between sources ($n = 5$). Search results were then analysed in terms of how each article framed the term UHI (see Table 2). The search phrase ‘urban heat island’ identified four main frames which had consistent narratives of relevance. These were: the top down mitigation of UHI, the bottom up mitigation of UHI, the climate change debate and distribution of health risks and vulnerabilities. Four other minor narratives appeared, these were: weather, general science, education and economics, however due to the relatively small number of articles belonging to these narratives they have been excluded from further analysis.

5.1. Top down mitigation frame

The top down mitigation frame focuses on government bodies; local council, state and national government and their response to

Table 2

Frames that appeared in the media review and an explanation of the frame. These numbers include no duplication between or within publications.

Frame	No.	Explanation
Top down mitigation	38	This frame focuses on government bodies; local council, state and national government and their response to UHI. The role of government bodies in relation to UHI was typically in the context of planning to prevent, mitigate or consider the effect of UHI on their constituents and/or local environment.
Bottom up mitigation	14	This frame is generally focused on small scale urban greening efforts of individuals, local business, larger business/corporations and universities to combat UHI. These efforts span from individuals planting tree to business using climate friendly building methods.
Risks and vulnerabilities	14	Articles were generally centered on communicating the findings of relevant research studies, which included reporting on the distribution of health risks and identifying heat vulnerabilities, i.e. how heat is likely to impact on different parts of the population.
Climate Change Debate	13	Articles which clearly positioned UHI within the context of debating the existence of climate change. Within this narrative half the articles refer to the UHI to support climate sceptics and debate climate science. While the other half are articles responding to the arguments proposed by climate sceptics e.g. fact checking articles.
Weather	8	Articles which were centered on extreme weather events with references to UHI as a product, factor or potential hazard of extreme heat.
General Science	4	Articles which reference UHI in relation to its effect on urban ecology such as the reproduction of spiders and the frequency of frosts.
Education	3	Articles which focus on education communication of the impacts of UHI.
Economics	1	Articles which positioned UHI purely in economic terms.

UHI. The three levels of government are presented differently in the articles in this frame. Local council is presented as being both aware and proactive in regard to UHI, primarily motivated by concern for the local community; in particular its vulnerable populations. In Balding's (2015, p. 45) article about Penrith Council's 'Cooling the City Strategy' the issue is framed in regard to the effect that it will have on local community members:

St Marys mother of three Kelly Hobson hopes the study leads to a cool change. "I don't have airconditioning [SIC], so I run fans and try to get to places that do have airconditioning [SIC]," she said. "Besides shopping centres, there really is nowhere close to home to go." Council senior sustainability planner Jen Guice said a cooling strategy was needed to protect people at-risk of extreme heat.

Furthermore, in *Cooler, smarter bus shelters wanted*, Cormack (2016a) links heat vulnerability with socioeconomic status and acknowledges the interconnectedness of climate change and UHI.

Within media results local councils are reported on as having multiple governance approaches to reducing UHI, including; researching and mapping hotspots, addressing UHI through strategic planning, and engaging the community to contribute to positive urban climate impacts through tree planting and cool bus stop design. The approach of local councils are depicted in a positive light; 'The City of Melbourne's urban forest strategy has turned an environmental crisis into a world-beating success story... "It wasn't just tree losses that inspired us, but the urban heat-island effect..."' (Studdert, 2015, p. 27), with the actions of local councils reported on as innovative and necessary 'to prepare for climate change by providing a green antidote to urban heat sinks, creating healthier ecosystems and improving the city's water usage.' (Studdert, 2015, p. 27).

The only article sceptical of local council actions to reduce UHI was: *Just a shade ambitious Council is ready to go out on a limb to keep Sydney cool* in which the City of Sydney is depicted as overenthusiastic about tree planting with their plan to 'boost the tree-top canopy...by 75 per cent' (Capion, 2012, p. 17). The author comments 'The city already has nearly 30,000 street trees and 12,000 park trees but the council report said a lack of shade had left much of the city with the "urban heat island effect"' (Capion, 2012, p. 17). While this article framed local councils taking action on UHI sceptically, it was, however, the exception to the dominant narrative of the other articles.

Contrary to the depiction of local government, federal and state governments are presented, at best, as lagging, or at worst as working against the good intentions of local government. In *Suburbs combat extreme 'heat island' effect to cool off*, Cormack (2016b) focuses on the gap between future policy and contemporary solutions to deal with the effects of UHIs in Western Sydney. Consequently, it is noted that local councils are no longer waiting for broad sweeping policy and are implementing their own programs; 'in western Sydney, where the heat is worst felt, councils aren't waiting for the Turnbull government's plan' (Cormack, 2016b, p. 14). Similar sentiments are conveyed in public opinion letters. In *Trees missed already* it is stated: 'Federal Environment Minister Greg Hunt's recent interest in urban tree canopy and the city heat island effect is almost too late in my part of Sydney...' and that his concern might be little more than 'hot air' (Hughes, 2016, p. 16). Another letter argues that the state government is actively working against the good intentions of local government:

At a public meeting last week in Blacktown, I learned about the changes that the Baird Government has in store for environmental laws in NSW that will weaken protection for threatened species.... These changes are the last thing NSW should be doing at a time when the world has agreed to limit global warming to 1.5 degrees, with the Federal Government acting at cross purposes in announcing a project to cool western Sydney from the "urban heat island effect" through tree planting. (Herrick, 2016, p.28)

Through analysing this frame in terms of actors and their role in addressing the issue of UHI it became clear that there were different narrative clusters constructed in relation the different levels of government. While overwhelmingly local council was viewed in a positive light, the actions of state and national government were critiqued.

Within this frame the causes and technical solutions to reduce UHI are discussed, with a general focus on the use of urban planning to mitigate urban heat. The temporal scale often varied from long term, with some articles voicing concerns regarding the future of Sydney in the context of population growth, to the short term, with many articles questioning how urban planning policies in Sydney will take steps to resolve urban heat crises now. The geographical scale also varied from the hyper-local to the state level. Despite the range in temporal and spatial scale, the articles all involved some recognition and expectation that UHI mitigation was the responsibility of official governing bodies' concern with urban planning; although, as noted there is an apparent central focus on the positive role of decentralized governmental decision making.

5.2. Bottom up mitigation frame

The bottom up UHI mitigation narrative is comprised of multiple reports and articles which involve different types and scale of urban greening to create a mosaic story of individual, community and industry approaches to redesigning the urban landscape. Contrary to the top down mitigation frame these articles are generally not contextually overlapping or politically opposed. What brings this frame together is the common theme that the actions of individuals or the private sector are contributing in a small way to reducing the UHI effect. Generally these articles address UHI from the perspective of urban greening, which covers topics from gardening to green design and building features.

In the case of *Growth spurt* (Maddocks, 2013, p. 24), the article focuses on do-it-yourself urban gardening and proposes the vertical garden as a valid option as '...they save space, reduce the urban-heat-island effect, help improve air quality and make cities generally more comfortable to live in.' Importantly, there is no reference or allusion to government institutions or planning processes, the article instead speaks to would be gardeners, emphasising the focus of on the actions of individuals evident within the bottom up

mitigation frame.

Young's (2012) article, *Green roof fad comes to town* (Young, 2012, p. 10), focuses on the growing trend of rooftop gardens – Green roofs – in Australia.

The burgeoning interest in green roofs is driven by their multiple environmental and social advantages. Greening a city's roofs is one of the best ways to combat the urban heat island effect...

The report notes how architectural design combined with urban greenery can be used to solve and resolve urban issues such as UHIs, noise pollution and building aesthetics. As with Maddocks' (2013) article there is no mention of state entities but rather focuses on the private sector and the incorporation of urban greening into high-end urban design.

In *Nature's friend* (Wong, 2016, p. 16), the article focuses on the design of a single house in Newtown. The design is considered eco-friendly as it includes '...a self-water green roof, an 8000-litre water tank, energy-efficient lights and appliances, a smart meter and energy monitoring...' it also has a large enough solar system to be energy self-sufficient. The company director is quoted describing the green roof as a habitat for native birds and a small contribution to reducing UHI. In this report mitigating the UHI effect has been incorporated into sustainable housing design by leading companies and similar to Young's (2012) report, has linked urban greening with luxury urban design.

The three examples provide an insight into the range of topics and areas which contribute to the bottom up mitigation frame. While they vary in topic, the scale and focus of the reports remains on responses to the issue of the UHI effect at the individual level – such as; urban gardening, horticulture and creating your own green feature wall: and at the level of private sector action –focusing on interior and exterior design and green architecture. The scale and focus is therefore starkly different to the top down government mitigation frame. This frame is hopeful in tone and positively reports on actions that individuals and the private sector are taking to address UHI.

5.3. Risks and vulnerabilities frame

This frame was identified through references to heat causing health risks and exacerbating sociodemographic or geographic vulnerabilities. In the article, *As shepherds watched, it got hotter and hotter*, Hannam (2014) states:

Human health – and that of other animals and even plants – is likely to become an ever more pressing public issue as temperatures rise with global warming, cities grow and populations age.

Discussion of risks and vulnerabilities focused on how these factors were unevenly distributed across the city. While some articles were general in their identification of risk "City residents are more vulnerable because of the Heat Island Effect (HIE)... which can add up to four degrees to temperatures." (AAP, 2013); other research indicated "the outer fringes" of Australian cities as the most vulnerable (Cubby, 2013, p. 3). Western Sydney was singled as an area of particular vulnerability in Sydney:

The effects of intense heat have not escaped the gaze of western Sydney councils, which are expected to experience between five and 10 additional hot days by 2030 due to rapid rates of construction.

Over the next 15 years, 180,000 homes will be built in western Sydney, a scale of growth likely to exacerbate an "urban heat island effect".

"Urban heat is an issue for all cities, but western Sydney's unique geography and lack of sea breeze means the region is already much hotter than its eastern counterparts," said Councillor Tony Hadchiti, president of the Western Sydney Regional Organisation of Councils (WSROC)." (Cormack, 2016c)

In most cases the temporal scope of these articles included a present and future aspect, speculating how future weather patterns will impact society based on what is being experiencing in the 'now'. This frame drew together concepts of climate change, extreme weather events and risk management. Within this frame climate change is positioned as a direct driver of extreme weather and associated UHI as an amplifier of extreme weather events and climate change – consistent with the literature (Kalnay & Cai, 2003; Santamouris et al., 2015; Edmondson et al., 2016).

However, within this frame the occasional technical detail was noted to be miscommunicated. In the article *'Death from heatwaves to rise 'without emission cuts'*, the concept of UHIs was directly linked to amplifying the impacts of heatwaves in the context of climate change. While Cubby (2011b) did correctly associate health risks, climate change and UHIs the following quote raises concerns regarding the general understanding and communication of UHI theory in the public: '...people in cities usually endured temperatures one to three degrees higher due to the "urban heat island" effect, under which reflective surfaces tend to contain heat.' Within the literature it is widely noted reflective surfaces actually reduce UHI as heat energy is not absorbed by the urban skin (Akbari et al., 2016; Phelan et al., 2015; Rizwan et al., 2008).

Linguistic analysis of the use of the term UHI in this frame revealed that within a significant portion of the articles UHI, or an aspect of UHI such as heat islands, have been presented in quotation marks or suggestive adjectives. Evident in the quotes from Cubby (2011b) and (Cormack, 2016c) above, and Hannam (2015) who refers to UHI as: '...the so-called urban heat island'. This is significant because the use of quotation marks and suggestive adjectives implies the concept of UHIs is either not fully understood, confusing, ambiguous and/or provokes scepticisms (Fairclough, 2003). Fairclough (2003) refers to this as linguistic pragmatism.

5.4. Climate change debate frame

This frame focused on the debate regarding the scientific consensus of climate change and its relationship to UHIs. Within this frame, articles generally fell into two categories; half of the articles refer to the UHI effect as a means to support climate sceptics and debate climate science, the other half are responses to the arguments proposed by climate sceptics e.g. fact checking articles. Therefore, articles in this frame represented UHI in two vastly differing ways. In the following examples UHI was referenced in regard to challenging or supporting the dominant narrative of climate science.

In *Last summer was not actually angrier than other summers* (Salby, 2013, p. 10) UHI is used as a scientific theory to question climate change and the validity of the Climate Commission: “Station measurements are therefore biased through the so-called urban heat island effect.” The premise of the argument posed by Salby (2013) is: climate change is actually not occurring and the scientific institutions which report on the issue are wrong because UHI is being interpreted as global warming. UHI in this case was technically used accurately – UHI does cause localized warming in urban-built-up environments (Edmondson et al., 2016) – but applied out of context. Within the literature UHI is discussed as being part of a complex positive feedback system in which climate change and UHIs are interlinked (Santamouris et al., 2015).

The reported misuse of UHI is not always as evident as it was in *Last summer was not actually angrier than other summers*. In *A hot spell forever* UHI is mentioned as a point on contention:

Most of the evidence of higher temperatures, he says, comes from land-based city measuring stations... “We might have measured nothing more than the expansion of cities and urban heat islands.” (Beale, 2014)

While the article then goes on to argue the existence of climate change and the need for climate action, the subject of UHI is not returned to again, therefore it leaves the concept hanging as an alternative argument that might continue to be used to dispute climate predictions.

In *Climate sceptics unmoved by scientist's about-face* (Cubby, 2012, p. 7) UHI was used by sceptics as evidence challenging the accuracy and validity of climate change:

“If [Professor Muller's study] removed stations that are near concrete, car parks, airports and airconditioners[SIC], and used only the best data we have, I'd be open to accept their warming trend calculations,” she said. “But even so, it's another leap entirely to say that just because the world has warmed that it's man-made.”

The above extract clearly highlights the debate around data accuracy. In the report Jo Nova (quoted by Cubby above) describes factors contributing to UHI and identifies them as factors that undermine global meteorological data collection. The author (Cubby) interjects there, stating:

The “urban heat island effect” is real – it has been documented by meteorologists for decades – but the Bureau of Meteorology removes suspect thermometer sites from its climate change measurements. (Cubby, 2012, p. 7).

Therefore, Cubby (2012) argues that, counter to the arguments of the climate sceptics, the phenomena of climate change and the UHI effect can co-exist. However, overall the article highlights a greater contextual issue in which UHI is used in conjunction with conspiracy style logic. For example, Malcom Roberts is quoted saying:

The UN's climate front is just a part of the overall UN ‘Agenda 21’, which is the sustainability program and the biodiversity program ... But the biggest one's the UN agenda for global governance. (Cubby, 2012, p. 7)

Furthermore, in *The science is in but it's still a numbers game* (Cubby, 2011a, p.16) UHI is also mentioned as an argument questioning climate change: ‘...or maybe the urban “heat island” effect fooling our thermometers.’ However, as the overall article acknowledges the reality of climate change, this reference alludes to how UHI has been misused within climate change ‘debates’ previously. Within the climate change debate frame, UHI is misused and abused in order to support arguments and undermine others. In these cases, references to the UHI effect are applied out of context leading to the miscommunication of the UHI effect. Analysis of the use of tone and language in this frame highlight how references to UHI are framed in a highly contentious manner.

6. Discussion

Studies of UHI within academic literature are increasing. In the Australia context, the study of the UHI effect is gaining traction both from an academic and governmental perspective as evidenced in the literature review. The results of our media study show that the UHI effect is discussed in Sydney media over the period of the study. This indicates that the UHI effect has a relative degree of issue salience on media agenda over this period. The issue salience of the UHI effect is also reflected to a larger extent in the increasing body of academic literature and governmental studies on the UHI effect in Australia.

In regard to framing and the salience of issue attributes, generally, there was a strong emphasis on actors and actions to mitigate UHI reported on by media as illustrated in the prominent ‘top-down mitigation’ frame. This emphasis was usually contextualised within the discussion of larger issues such as governance and/or urban planning. When UHI was discussed from the perspective of state or national level government action it tended to be referred to in the context of something that needed to be addressed – or that future planning should account for and plan against, highlighting inaction on the part of state and national government. This is symptomatic of the wider national lag in climate change mitigation efforts.

Predominantly, however, local government actors were portrayed in a positive and proactive manner as they were reported on as

taking action to understand how UHI affected their communities and were putting in place effective mitigation strategies. Therefore, when analysed, this frame highlights the importance of local action to environmental issues. Corburn (2009, p. 413) shows how local action on UHI provide an effective platform to 'localise environmental science' in the context of their 'social setting', leading to more effective and 'publicly accountable decision-making related to urban climate change'. Interestingly, the findings of our media analysis also reflect that local council actions on UHI in Sydney were not only more advanced than those of other levels of government, but were also less contentiously reported on, highlighting, that the findings of Corburn (2009) and Hintz et al. (2017) are highly applicable in Sydney.

The bottom-up frame while prevalent tended to only mention UHI in passing when listing a suite of benefits that a new green development might have or how the cooling effect of urban greenery might help with the UHI effect. UHI is referred to without contention in this frame. Actors in this frame are described as having a positive impact on UHI through gardening or green building practices. Therefore, the frame is hopeful in tone and positively reports on actions that individuals and business are taking to address UHI. Although it should be noted that there is a marketability aspect to this frame that is focused on green real-estate, or greening products to help mitigate the UHI effect. In both the top-down and bottom-up frames emphasis is placed on urban greening initiatives which positively align with recommendations from the academic literature (Lehmann, 2014; Norton et al., 2015; Livesley et al., 2016; Lin et al., 2016). However, while the scale of urban green initiatives is evident in the top-down frame, from the bottom-up frame the scale of action is unknowable and therefore the degree to which UHI effect is mitigated through bottom-up action is unclear.

In the risk and vulnerability frame, the UHI effect is discussed in a more focused manner. Articles in this frame tended to focus around how the UHI effect was unevenly distributed across the city. The themes identified in this frame link in with the discourse of environmental justice, which has been described as focusing on 'local impacts and experience, inequitable vulnerabilities, the importance of community voice, and demands for community sovereignty and functioning' (Schlosberg and Collins, 2014, p. 359). However, this frame's technical tone and focus on presenting research and mapping of UHI effects prevents it from conveying community voice or sovereignty. Nevertheless, the identification of this frame provides evidence of a positive media contribution to considering the diversity of climate impacts and mitigation at a local scale.

The consideration of language provided insight into how UHI theory is reported in media in Sydney. In many cases, the phrase 'urban heat island', 'urban heat island theory' and/or 'urban heat island effect' was introduced as the 'apparent' or 'so called' while the phrase itself was referenced to in quotation marks. This is important as UHIs are introduced and referenced with possible caution and uncertainty (Fairclough, 2003), something which is not evident within academic literature. It also implies the author has a limited knowledge of UHI theory (which is supported by general misreporting on UHIs) and/or the authors do not expect the intended audience to have an understanding of UHI theory. The ambiguous and/or cautious manner in which the UHI effect is referred to has potentially negative consequences regarding science communication and citizen understandings of science.

Furthermore, tone was highly influential in the climate change debate narrative. Within the climate change debate narrative scientific understandings of UHI were deconstructed and used out-of-context in order to create an aggressive counter argument to climate change. The climate change debate frame complicates the representation of UHI within the media as it generates two different meanings; UHIs are linked to climate change and UHIs are independent of climate change. The contextualisation of the UHI effect within the climate change debate frame was unexpected, largely because this logic is not represented in the UHI literature and thus not considered during the design of this research. This particular framing may have negative resultant policy implications for both UHI and climate change mitigation (Soroka, 2002). It should, however, be noted that this debate was most prevalent between 2011 and 2013, with 8 of the 13 articles occurring in this period. The majority of references to UHI in these articles were made in relation to Professor Muller's work to disprove climate change:

Professor Muller's research team examined two chief criticisms by sceptics. One is that weather stations are unreliable; the other is that cities, which create heat islands, were skewing the temperature analysis. (Cubby, 2012).

Despite Muller's research findings confirming the existence of climate change the study sparked debate on both sides of the climate debate around this period. This finding can be interpreted in two ways. Firstly, that UHI has become a less controversial term or secondly that no politically controversial research has recently been published relating to UHI.

7. Conclusions

The findings of this article highlight that the phenomena of UHI received attention within national, state and local Sydney media over the study period. Framing analysis of the results revealed overall positive reportage on actions taken to mitigate UHI, particularly local government action on UHI mitigation. The discussion of UHI was most detailed regarding the distribution of risks posed to the health of different segments of the population. However, media analysis undertaken in this article further highlights the importance of tone and language in the communication of scientific knowledge and has drawn attention to the potential effect this might have on the public's understanding of UHI.

In media articles reviewed, when UHI was mentioned in the context of climate change this tended to bring an element of contention into its use. This highlights that climate change is still a politicised term within media at various scales, and that related scientific concepts such as the UHI effect can also become maligned when framed in relation to climate change. The use of 'the apparent' or 'so called' urban heat island (which in itself was often found to be in quotation marks), indicates possible caution and uncertainty within media reporting, and potentially among readers, which is something not evident within the corresponding academic literature.

Overall, vigilance in relation to these terms is necessary given that climate change is predicted to continue the heating of the

planet, the urban heat effect is likely to exacerbate and magnify heat impacts in urban areas, and that processes of urbanization and densification of existing urban areas are likely to result in higher numbers of people being impacted. In order to reduce these impacts through policy and changes in urban planning and design, it is necessary to inform politicians and policy makers. Media is therefore an important bridge between scientific literature and political agenda-setting. Furthermore, it is necessary to have an educated public aware of the causes, implications and options for dealing with urban heat and the wider issue of anthropogenic climate change, in order to support or prompt politicians to act. As such, media reporting is also an important bridge between scientific study and the everyday experience of residents experiencing these impacts – a connection that is likely to generate political pressure depending on how media report these issues. How media re(present) issues of urban heat and climate change is therefore of great import.

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